



Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection

Downloaded from <https://aidsinfo.nih.gov/guidelines> on 8/31/2020

Visit the *AIDSinfo* website to access the most up-to-date guideline.

Register for e-mail notification of guideline updates at <https://aidsinfo.nih.gov/e-news>.

Adherence to Antiretroviral Therapy in Children and Adolescents Living with HIV (Last updated April 14, 2020; last reviewed April 14, 2020)

Panel's Recommendations

- Strategies to maximize adherence should be discussed **before and/or at initiation** of antiretroviral therapy (ART) and again before changing regimens **(AIII)**.
- Adherence to therapy must be assessed and promoted at each visit, and strategies to maintain and/or improve adherence must be continually explored **(AIII)**.
- In addition to viral load monitoring, at least one other method of measuring adherence to ART should be used **(AIII)**.
- Once-daily antiretroviral regimens and regimens with a low pill burden should be prescribed whenever feasible **(AII*)**.

Rating of Recommendations: A = Strong; B = Moderate; C = Optional

Rating of Evidence: I = One or more randomized trials in children† with clinical outcomes and/or validated endpoints; I* = One or more randomized trials in adults with clinical outcomes and/or validated laboratory endpoints with accompanying data in children† from one or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; II = One or more well-designed, nonrandomized trials or observational cohort studies in children† with long-term outcomes; II* = One or more well-designed, nonrandomized trials or observational studies in adults with long-term clinical outcomes with accompanying data in children† from one or more similar nonrandomized trials or cohort studies with clinical outcome data; III = Expert opinion

† Studies that include children or children/adolescents, but not studies limited to post-pubertal adolescents

Background

Adherence to antiretroviral therapy (ART) is a principal determinant of virologic suppression. Suboptimal adherence may include missed or late doses, treatment interruptions and discontinuations, and subtherapeutic or partial dosing.^{1,2} Poor adherence will result in subtherapeutic plasma antiretroviral (ARV) drug concentrations, facilitating the development of resistance to one or more drugs in a given regimen and possible cross-resistance to other drugs in the same class. Multiple factors (including regimen potency, pharmacokinetics, drug interactions, viral fitness, and the genetic barrier to ARV resistance) influence the adherence-resistance relationship.³ In addition to compromising the efficacy of the current regimen, suboptimal adherence can limit the options for future effective drug regimens in patients who develop multidrug-resistant HIV; it can also increase the risk of secondary transmission of drug-resistant virus.

Poor adherence to ARV drugs is commonly encountered in the treatment of children and adolescents living with HIV. A variety of factors—including medication formulation, frequency of dosing, drug toxicities and side effects, child's age and developmental stage, as well as psychosocial, behavioral, and sociodemographic characteristics of children and caregivers—have been associated with nonadherence. However, no consistent predictors of either good or poor adherence in children have been identified.⁴⁻⁶ Several studies have demonstrated that adherence is not static and can vary with time on treatment.⁷ **More recently, findings from the U.S. Pediatric AIDS/HIV Cohort Study (PHACS) demonstrated that the prevalence of nonadherence increased with age. Among 381 children and adolescents with perinatal HIV infection, the prevalence of nonadherence increased from 31% to 50% ($P < 0.001$) and the prevalence of unsuppressed viral loads increased from 16% to 40% ($P < 0.001$) between pre-adolescence and late adolescence/young adulthood.**⁸ These findings illustrate the difficulty of maintaining high levels of adherence and underscore the need to work with patients and their families to ensure that adherence education, support, and assessment are integral components of care.

Specific Adherence Issues in Children

Adherence is a complex health behavior that is influenced by the drug regimen, patient and family factors, and the patient-provider relationship.^{9,10} **Despite improvements over the last several years, the** limited availability of once-daily and single-tablet regimens and palatable formulations for infants and young

children remains especially problematic.¹¹ Furthermore, infants and children are dependent on others for medication administration; adult caregivers may face barriers that contribute to nonadherence in children, including forgetting doses, changes in routine, being too busy, and child refusal.^{12,13} Some caregivers may place too much responsibility for managing medications on older children and adolescents before they are developmentally able to undertake such tasks.¹⁴ Adherence may also be jeopardized by social and health issues within a family (e.g., substance abuse, poor physical or mental health, unstable housing, poverty, violence, involvement with the criminal justice system, limited social support).^{15,16}

Adherence Assessment and Monitoring

Clinicians should begin assessing potential barriers to adherence and discussing the importance of adherence with patients before initiating or changing an ARV regimen. Evaluations should assess social and behavioral factors that may influence adherence and should identify individual needs for intervention. Clinicians should ask patients about their experience with taking medications, as well as concerns and expectations about treatment. Before beginning treatment, it is important that the patient explicitly agrees to the treatment plan, which should include strategies to support adherence. It is also important to alert patients to potential adverse effects of ARV drugs (e.g., nausea, headaches, abdominal discomfort, sleep disturbances), explain how they can be managed, and emphasize the importance of informing the clinical team if they occur.

A routine adherence assessment should be incorporated into every clinic visit. Adherence is difficult to assess accurately; different methods of assessment have yielded different results, and each approach has limitations.¹⁷⁻¹⁹ Viral load monitoring is the most useful indicator of adherence and is a routine component of monitoring individuals who are on ART (see [Plasma HIV-1 RNA \[Viral Load\] and CD4 Count Monitoring](#) in the [Adult and Adolescent Antiretroviral Guidelines](#)). In addition, it can be used as positive reinforcement to encourage continued adherence.²⁰ Clinicians should use at least one other method to assess adherence in addition to monitoring viral load.¹⁸ Table 13 includes common approaches to monitoring medication adherence.

Strategies to Improve and Support Adherence

When there are concerns about adherence, a patient should be seen and/or contacted frequently (by phone, text messaging, email, and social networking, as allowed within the context of local legal and regulatory requirements) to assess adherence and to determine the need for strategies that can improve and support adherence. During the first month of **treatment (or a regimen change)**, a patient can be contacted weekly, or even daily, if necessary.

Strategies should include simplifying the drug regimen, developing treatment plans that integrate medication administration into daily routines (e.g., associating medication administration with daily activities such as brushing teeth), and optimizing the use of social and community support services. Multifaceted approaches that include regimen-related strategies; educational, behavioral, and supportive strategies focused on children and families; and strategies that focus on health care providers may be more effective than one specific intervention. Table 14 summarizes some of the strategies that can be used to support and improve adherence to ARV medications. The Centers for Disease Control and Prevention (CDC) offers a [web-based toolkit](#) (consisting of four evidence-based HIV medication adherence strategies) to HIV care providers.²¹

Regimen-Related Strategies

ARV regimens for infants and young children often require taking multiple daily doses of multiple pills or liquids, some of which are unpalatable and each of which has the potential for adverse effects (AEs) and drug interactions. To the extent possible, regimens should be simplified with respect to the number of pills or volume of liquid prescribed, as well as the number of daily doses, and drugs in the regimen should be chosen to minimize drug interactions and AEs.²² Efforts should be made to reduce the pill burden and pill size and to prescribe once-daily ARV regimens and single-tablet regimens whenever feasible (see Table 16 in [Management of Children Receiving Antiretroviral Therapy](#)). With the introduction of new drug classes and a wider array of

once-daily formulations, including some medications that are now available in a small pill size, there are now more options for less toxic, simplified regimens, particularly for older children and adolescents. Several studies in adults have demonstrated better adherence with once-daily ARV regimens than with twice-daily regimens, and better adherence with single-tablet formulations than with multiple-tablet regimens.^{11,23-26} [Appendix A, Table 1](#) shows which ARV drugs are available in fixed-dose combination (FDC) tablets, and [Appendix A, Table 2](#) provides information about minimum body weight requirements and other considerations when using FDC tablets in children.

When nonadherence is related to the poor palatability of a liquid formulation or crushed pills, the offending taste can sometimes be masked with a small amount of flavoring syrup or food if simultaneous administration of food is not contraindicated (see [Appendix A: Pediatric Antiretroviral Drug Information](#)).²⁷ Unfortunately, the taste of lopinavir/ritonavir cannot be masked with flavoring syrup. A small study of children and youth aged 4 years to 21 years found that training children to swallow pills was associated with improved adherence at 6 months post-training.²⁸ Finally, if drug-specific toxicities are thought to be contributing to nonadherence, efforts should be made to alleviate the AEs by changing the particular drug (or, if necessary, the drug regimen) when feasible.

Patient/Family-Related Strategies

Patient and caregiver education is an essential component of establishing good medication adherence in children. Educating families about adherence should begin before initiating or changing ARV medications and should include a discussion of the goals of therapy, the importance of optimizing adherence, and the specific plans for supporting and maintaining a child's medication adherence. Caregiver adherence education strategies should include the provision of both information and adherence tools, such as written and visual materials; a daily schedule illustrating times and doses of medications; and demonstration of the use of syringes, medication cups, and pillboxes. Additionally, it may be helpful to assess the medication adherence of the caregiver or other household members who currently take ARV drugs or other chronic medications.

Several behavioral tools can be used to integrate taking medications into a child's daily routine. The use of behavior modification techniques, especially the application of positive reinforcements and the use of small incentives (including financial incentives) for taking medications, can be effective tools to promote adherence.²⁹ Treating mental health disorders (e.g., depression) may facilitate adherence to complex ARV regimens.^{30,31}

In situations where the child has not been informed of their HIV status, HIV disclosure should be discussed with the caregivers. In a recent review that explored the relationship between ART adherence and disclosure, five studies linked disclosure to improved adherence, four studies found that disclosure led to worse adherence among study participants, and five studies found no association.³² Therefore, the decision to disclose HIV status should not necessarily be expected to improve adherence. The decision should instead be based on a comprehensive assessment of the psychosocial milieu and the needs of the child and family.

In poorly adherent children who are at risk of disease progression and who have severe and persistent aversion to taking medications, the use of a gastrostomy tube may be considered.³³ If adequate resources are available, home-nursing interventions or directly observed therapy (DOT) may also be beneficial. **The evidence is mixed as to the efficacy of programs that are designed to improve adherence** through DOT, but DOT may still be a useful strategy for some patients.³⁴⁻³⁶

Other strategies to support adherence include using mobile applications (apps) that remind patients to take medications; setting patients' cell phone alarms to go off at medication times; sending text-message reminders; conducting motivational interviews; providing pill boxes, blister packaging, and other adherence support tools; and delivering medications to the home. The CDC has an adherence toolbox, which includes a free mobile app (CDC's Every Dose Every Day mobile app) that is available through their [website](#).

A recent systematic review of studies that evaluated the use of mobile phone technologies to improve ART adherence concluded that the use of mobile short message service (SMS) interventions improved adherence to ART compared with control conditions. A recent systematic review of studies that evaluated the use of mobile

phone technologies to improve ART adherence reported mixed results; the efficacy of SMS interventions varied depending on the specific SMS intervention tested.³⁷ Another recent systematic review of the effectiveness of using mobile phone interventions to improve adherence to ART also reported mixed results; effectiveness varied depending on the measured outcomes and the specific intervention (e.g., whether the study evaluated the use of texts or the use of phone calls).³⁸ It should be noted, however, that the evidence base for effective adherence interventions in adolescents and young adults who are taking daily ART is limited.³⁹⁻⁴⁴

Health Care Provider-Related Strategies

To improve and support adherence, providers should maintain a nonjudgmental attitude, establish trust with patients and caregivers, and identify mutually acceptable goals for care. Providers can improve adherence through their relationships with patients' families. This process begins early in a provider's relationship with a family, when the clinician obtains explicit agreement about the medication and treatment plan and any further strategies to support adherence. Fostering a trusting relationship and engaging in open communication are particularly important. Provider characteristics that have been associated with improved patient adherence in adults include consistency, willingness to give information and ask questions, technical expertise, and commitment to follow-up. Creating an environment in the health care setting that is child-centered and includes caregivers in adherence support also has been shown to improve treatment outcomes. Immigrant children and families may face unique social and cultural issues; it is important to recognize these issues and facilitate establishing links to community resources, particularly for families who are recent immigrants. Providing comprehensive multidisciplinary care (e.g., with nurses, case managers, pharmacists, social workers, psychiatric care providers) may also better serve more complex patient and family needs, including adherence.

Table 13. Approaches for Monitoring Medication Adherence

Routine Assessment of Medication Adherence in Clinical Care^a	Description
Monitor viral load.	Viral load monitoring should be done more frequently after initiating or changing medications. ^a
Assess a quantitative self-report of missed doses.	Ask the patient and/or caregiver about the number of missed doses over a defined period (1, 3, or 7 days).
Request a description of the medication regimen.	Ask the patient and/or caregiver about the name, appearance, and number of medications, and how often the medications are taken.
Assess barriers to medication administration.	Engage the patient and caregiver in a dialogue about potential barriers to adherence and strategies to overcome them.
Monitor pharmacy refills.	Approaches include a pharmacy-based or clinic-based assessment of on-time medication refills.
Conduct announced and unannounced pill counts.	Approaches include asking patients to bring medications to the clinic, home visits, or referral to community health nursing.
Targeted Approaches to Monitoring Adherence in Special Circumstances	Description
Implement DOT.	Include a brief period of hospitalization if indicated.
Measure drug concentration in plasma or DBS .	Measuring drug concentrations can be considered for particular drugs.
Approaches to Monitoring Medication Adherence in Research Settings	Description
Measure drug concentrations in hair.	Measuring hair drug concentrations can be considered for particular drugs; it provides a good measure of adherence over time. ^{17,45,46}
Use electronic monitoring devices.	Approaches include MEMS caps and Wisepill.
Use cell phone-based technologies.	Approaches include interactive voice response, text messaging, and mobile apps.

^a See [Clinical and Laboratory Monitoring of Pediatric HIV Infection](#) regarding the frequency of adherence assessment after initiating or changing therapy.

Key: apps = applications; **DBS = dried blood spots**; DOT = directly observed therapy; MEMS = Medication Event Monitoring System

Table 14. Strategies to Improve Adherence to Antiretroviral Medications

Initial Intervention Strategies
<ul style="list-style-type: none"> • Establish trust and identify mutually acceptable goals for care. • Obtain explicit agreement on the need for treatment and adherence. • Identify depression, low self-esteem, substance abuse, or other mental health issues in the child/adolescent and/or the caregiver that may affect adherence. Evaluate and initiate treatment for mental health issues before starting ARV drugs, if possible. • Determine whether the child is aware of their HIV status. Consider talking to the child's caregivers about disclosing this information to the child in a developmentally appropriate way. • Identify family, friends, health team members, and others who can support adherence. • Educate the patient and family about the critical role of adherence in therapy outcome, including the relationship between partial adherence and resistance and the potential impact on future drug regimen choices. Develop a treatment plan that the patient and family understand and to which they feel committed. • Work with the patient and family to make specific plans for taking medications as prescribed and for supporting adherence. Assist them in arranging administration during day care, school, and in other settings, when needed. Consider home delivery of medications. • Establish a patient's readiness to take medication by staging practice sessions or by other means. • Schedule a home visit to review medications and determine how they will be administered in the home setting. • In certain circumstances, consider a brief period of hospitalization at the start of therapy for patient education and to assess the tolerability of the chosen medications.
Medication Strategies
<ul style="list-style-type: none"> • Choose the simplest regimen possible; reduce dosing frequency, pill size, and number of pills (see Appendix A, Table 1 and Appendix A, Table 2). • When choosing a regimen, consider the patient's daily and weekly routines and potential variations in patient and family activities. • Choose the most palatable medicine possible (pharmacists may be able to add syrups or flavoring agents to increase palatability). • Choose drugs with the fewest AEs; provide anticipatory guidance for managing AEs. • Simplify food requirements for medication administration. • Prescribe drugs carefully to avoid adverse drug-drug interactions. • Assess pill-swallowing capacity and offer pill-swallowing training and aids (e.g., pill-swallowing cup, pill glide). Adjust pill size as needed.
Follow-Up Intervention Strategies
<ul style="list-style-type: none"> • Have more than one member of the multidisciplinary team monitor adherence at each visit and in between visits by telephone, email, text, and social media, as needed. • Provide ongoing support, encouragement, and understanding of the difficulties associated with maintaining adherence to daily medication regimens. • Use patient education aids, including pictures, calendars, and stickers. • Encourage the use of pill boxes, reminders, mobile apps, alarms, and timers. • Provide follow-up clinic visits, telephone calls, and text messages to support and assess adherence. • Provide access to support groups, peer groups, or one-on-one counseling for caregivers and patients, especially for those with known depression or drug use issues that are known to decrease adherence. • Provide pharmacist-based adherence support, such as medication education and counseling, blister packs, refill reminders, automatic refills, and home delivery of medications. • Consider DOT at home, in the clinic, or, in certain circumstances, during a brief period of inpatient hospitalization. • Consider gastrostomy tube use in certain circumstances. • Information on other interventions to consider can be found at the Complete Listing of Medication Adherence Evidence-Based Behavioral Interventions on CDC's website. • Consult the CDC Every Dose Every Day toolkit.

Key: apps = applications; ARV = antiretroviral; AE = adverse effect; CDC = Centers for Disease Control and Prevention; DOT = directly observed therapy

References

1. Vreeman RC, Nyandiko WM, Liu H, et al. Measuring adherence to antiretroviral therapy in children and adolescents in western Kenya. *J Int AIDS Soc.* 2014;17:19227. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25427633>.
2. Hawkins A, Evangeli M, Sturgeon K, Le Prevost M, Judd A, Aalphi Steering Committee. Episodic medication adherence in adolescents and young adults with perinatally acquired HIV: a within-participants approach. *AIDS Care.* 2016;28 Suppl 1:68-75. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26886514>.
3. Gardner EM, Burman WJ, Steiner JF, Anderson PL, Bangsberg DR. Antiretroviral medication adherence and the development of class-specific antiretroviral resistance. *AIDS.* 2009;23(9):1035-1046. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19381075>.
4. MacDonell KK, Jacques-Tiura AJ, Naar S, Fernandez MI, ATNP 086/106 Protocol Team. Predictors of self-reported adherence to antiretroviral medication in a multisite study of ethnic and racial minority HIV-positive youth. *J Pediatr Psychol.* 2016;41(4):419-428. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26498724>.
5. Gray ME, Nieburg P, Dillingham R. Pediatric human immunodeficiency virus continuum of care: a concise review of evidence-based practice. *Pediatr Clin North Am.* 2017;64(4):879-891. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/28734516>.
6. Schlatter AF, Deathe AR, Vreeman RC. The need for pediatric formulations to treat children with HIV. *AIDS Res Treat.* 2016;2016:1654938. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27413548>.
7. Giannattasio A, Albano F, Giacomet V, Guarino A. The changing pattern of adherence to antiretroviral therapy assessed at two time points, 12 months apart, in a cohort of HIV-infected children. *Expert Opin Pharmacother.* 2009;10(17):2773-2778. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19929700>.
8. Kacanek D, Huo Y, Malee K, et al. Nonadherence and unsuppressed viral load across adolescence among US youth with perinatally acquired HIV. *AIDS.* 2019. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/31274538>.
9. Haberer J, Mellins C. Pediatric adherence to HIV antiretroviral therapy. *Curr HIV/AIDS Rep.* 2009;6(4):194-200. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19849962>.
10. Shubber Z, Mills EJ, Nachega JB, et al. Patient-reported barriers to adherence to antiretroviral therapy: a systematic review and meta-analysis. *PLoS Med.* 2016;13(11):e1002183. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27898679>.
11. Clay PG, Nag S, Graham CM, Narayanan S. Meta-analysis of studies comparing single and multi-tablet fixed dose combination HIV treatment regimens. *Medicine (Baltimore).* 2015;94(42):e1677. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26496277>.
12. Marhefka SL, Koenig LJ, Allison S, et al. Family experiences with pediatric antiretroviral therapy: responsibilities, barriers, and strategies for remembering medications. *AIDS Patient Care STDS.* 2008;22(8):637-647. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18627275>.
13. Skovdal M, Campbell C, Madanhire C, Nyamukapa C, Gregson S. Challenges faced by elderly guardians in sustaining the adherence to antiretroviral therapy in HIV-infected children in Zimbabwe. *AIDS Care.* 2011;23(8):957-964. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21400306>.
14. Naar-King S, Montepiedra G, Nichols S, et al. Allocation of family responsibility for illness management in pediatric HIV. *J Pediatr Psychol.* 2009;34(2):187-194. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18586756>.
15. Cluver LD, Hodes RJ, Toska E, et al. 'HIV is like a tsotsi. ARVs are your guns': associations between HIV-disclosure and adherence to antiretroviral treatment among adolescents in South Africa. *AIDS.* 2015;29 Suppl 1:S57-65. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26049539>.
16. Cluver L, Meinck F, Toska E, Orkin FM, Hodes R, Sherr L. Multitype violence exposures and adolescent antiretroviral nonadherence in South Africa. *AIDS.* 2018;32(8):975-983. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/29547438>.
17. Pintye J, Bacchetti P, Teeraananchai S, et al. Brief report: lopinavir hair concentrations are the strongest predictor of viremia in HIV-infected Asian children and adolescents on second-line antiretroviral therapy. *J Acquir Immune Defic*

Syndr. 2017. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/28825944>.

18. Al-Hassany L, Kloosterboer SM, Dierckx B, Koch BC. Assessing methods of measuring medication adherence in chronically ill children—a narrative review. *Patient Prefer Adherence*. 2019;13:1175-1189. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/31413546>.
19. Craker L, Tarantino N, Whiteley L, Brown L. Measuring antiretroviral adherence among young people living with HIV: observations from a real-time monitoring device versus self-report. *AIDS Behav*. 2019;23(8):2138-2145. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/30888573>.
20. Bonner K, Mezochow A, Roberts T, Ford N, Cohn J. Viral load monitoring as a tool to reinforce adherence: a systematic review. *J Acquir Immune Defic Syndr*. 2013;64(1):74-78. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23774877>.
21. Centers for Disease Control and Prevention. Medication adherence. 2014.
22. Pham PA. Antiretroviral adherence and pharmacokinetics: review of their roles in sustained virologic suppression. *AIDS Patient Care STDS*. 2009;23(10):803-807. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19795999>.
23. Nacheha JB, Parienti JJ, Uthman OA, et al. Lower pill burden and once-daily antiretroviral treatment regimens for HIV infection: A meta-analysis of randomized controlled trials. *Clin Infect Dis*. 2014;58(9):1297-1307. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24457345>.
24. Pantuzza LL, Ceccato M, Silveira MR, Junqueira LMR, Reis AMM. Association between medication regimen complexity and pharmacotherapy adherence: a systematic review. *Eur J Clin Pharmacol*. 2017;73(11):1475-1489. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/28779460>.
25. Griffith DC, Farmer C, Gebo KA, et al. Uptake and virological outcomes of single- versus multi-tablet antiretroviral regimens among treatment-naïve youth in the HIV research network. *HIV Med*. 2019;20(2):169-174. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/30561888>.
26. Altice F, Evuarherhe O, Shina S, Carter G, Beaubrun AC. Adherence to HIV treatment regimens: systematic literature review and meta-analysis. *Patient Prefer Adherence*. 2019;13:475-490. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/31040651>.
27. Czyzewski D, Runyan D, Lopez M, et al. Teaching and maintaining pill swallowing in HIV-infected children. *The AIDS Reader*. 2000;10(2):88-95. Available at: <https://researchers.dellmed.utexas.edu/en/publications/teaching-and-maintaining-pill-swallowing-in-hiv-infected-children>.
28. Garvie PA, Lensing S, Rai SN. Efficacy of a pill-swallowing training intervention to improve antiretroviral medication adherence in pediatric patients with HIV/AIDS. *Pediatrics*. 2007;119(4):e893-899. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17353298>.
29. Foster C, McDonald S, Frize G, Ayers S, Fidler S. “Payment by Results”—financial incentives and motivational interviewing, adherence interventions in young adults with perinatally acquired HIV-1 infection: a pilot program. *AIDS Patient Care STDS*. 2014;28(1):28-32. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24428797>.
30. Sin NL, DiMatteo MR. Depression treatment enhances adherence to antiretroviral therapy: a meta-analysis. *Ann Behav Med*. 2014;47(3):259-269. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24234601>.
31. Bucek A, Leu CS, Benson S, et al. Psychiatric disorders, antiretroviral medication adherence and viremia in a cohort of perinatally HIV-infected adolescents and young adults. *Pediatr Infect Dis J*. 2018;37(7):673-677. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/29227462>.
32. Nichols J, Steinmetz A, Paintsil E. Impact of HIV-status disclosure on adherence to antiretroviral therapy among HIV-infected children in resource-limited settings: a systematic review. *AIDS Behav*. 2017;21(1):59-69. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27395433>.
33. Shingadia D, Viani RM, Yogev R, et al. Gastrostomy tube insertion for improvement of adherence to highly active antiretroviral therapy in pediatric patients with human immunodeficiency virus. *Pediatrics*. 2000;105(6):E80. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10835093>.
34. Bain-Brickley D, Butler LM, Kennedy GE, Rutherford GW. Interventions to improve adherence to antiretroviral therapy in children with HIV infection. *Cochrane Database Syst Rev*. 2011;12(12):CD009513. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22161452>.

35. Gaur AH, Belzer M, Britto P, et al. Directly observed therapy (DOT) for nonadherent HIV-infected youth: lessons learned, challenges ahead. *AIDS Res Hum Retroviruses*. 2010;26(9):947-953. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20707731>.
36. Hart JE, Jeon CY, Ivers LC, et al. Effect of directly observed therapy for highly active antiretroviral therapy on virologic, immunologic, and adherence outcomes: a meta-analysis and systematic review. *J Acquir Immune Defic Syndr*. 2010;54(2):167-179. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20375848>.
37. Amankwaa I, Boateng D, Quansah DY, Akuoko CP, Evans C. Effectiveness of short message services and voice call interventions for antiretroviral therapy adherence and other outcomes: A systematic review and meta-analysis. *PLoS One*. 2018;13(9):e0204091. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/30240417>.
38. Shah R, Watson J, Free C. A systematic review and meta-analysis in the effectiveness of mobile phone interventions used to improve adherence to antiretroviral therapy in HIV infection. *BMC Public Health*. 2019;19(1):915. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/31288772>.
39. Shaw S, Amico KR. Antiretroviral therapy adherence enhancing interventions for adolescents and young adults 13-24 Years of Age: a review of the evidence base. *J Acquir Immune Defic Syndr*. 2016;72(4):387-399. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26959190>.
40. Judd A, Sohn AH, Collins IJ. Interventions to improve treatment, retention and survival outcomes for adolescents with perinatal HIV-1 transitioning to adult care: moving on up. *Curr Opin HIV AIDS*. 2016;11(5):477-486. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/27272537>.
41. MacPherson P, Munthali C, Ferguson J, et al. Service delivery interventions to improve adolescents' linkage, retention and adherence to antiretroviral therapy and HIV care. *Trop Med Int Health*. 2015;20(8):1015-1032. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25877007>.
42. Kanters S, Park JJ, Chan K, et al. Interventions to improve adherence to antiretroviral therapy: a systematic review and network meta-analysis. *Lancet HIV*. 2017;4(1):e31-e40. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27863996>.
43. Camacho-Gonzalez AF, Gillespie SE, Thomas-Seaton L, et al. The metropolitan atlanta community adolescent rapid testing initiative study: closing the gaps in HIV care among youth in Atlanta, Georgia, USA. *AIDS*. 2017;31 Suppl 3:S267-S275. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/28665885>.
44. Casale M, Carlqvist A, Cluver L. Recent interventions to improve retention in HIV Care and adherence to antiretroviral treatment among adolescents and youth: a systematic review. *AIDS Patient Care STDS*. 2019;33(6):237-252. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/31166783>.
45. Olds PK, Kiwanuka JP, Nansera D, et al. Assessment of HIV antiretroviral therapy adherence by measuring drug concentrations in hair among children in rural Uganda. *AIDS Care*. 2015;27(3):327-332. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25483955>.
46. Chawana TD, Gandhi M, Nathoo K, et al. Defining a cutoff for atazanavir in hair samples associated with virological failure among adolescents failing second-line antiretroviral treatment. *J Acquir Immune Defic Syndr*. 2017;76(1):55-59. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/28520618>.